



Characterizing the Lakota Sandstone using 3D Seismic Data and Well Data: Teapot Dome, Wyoming

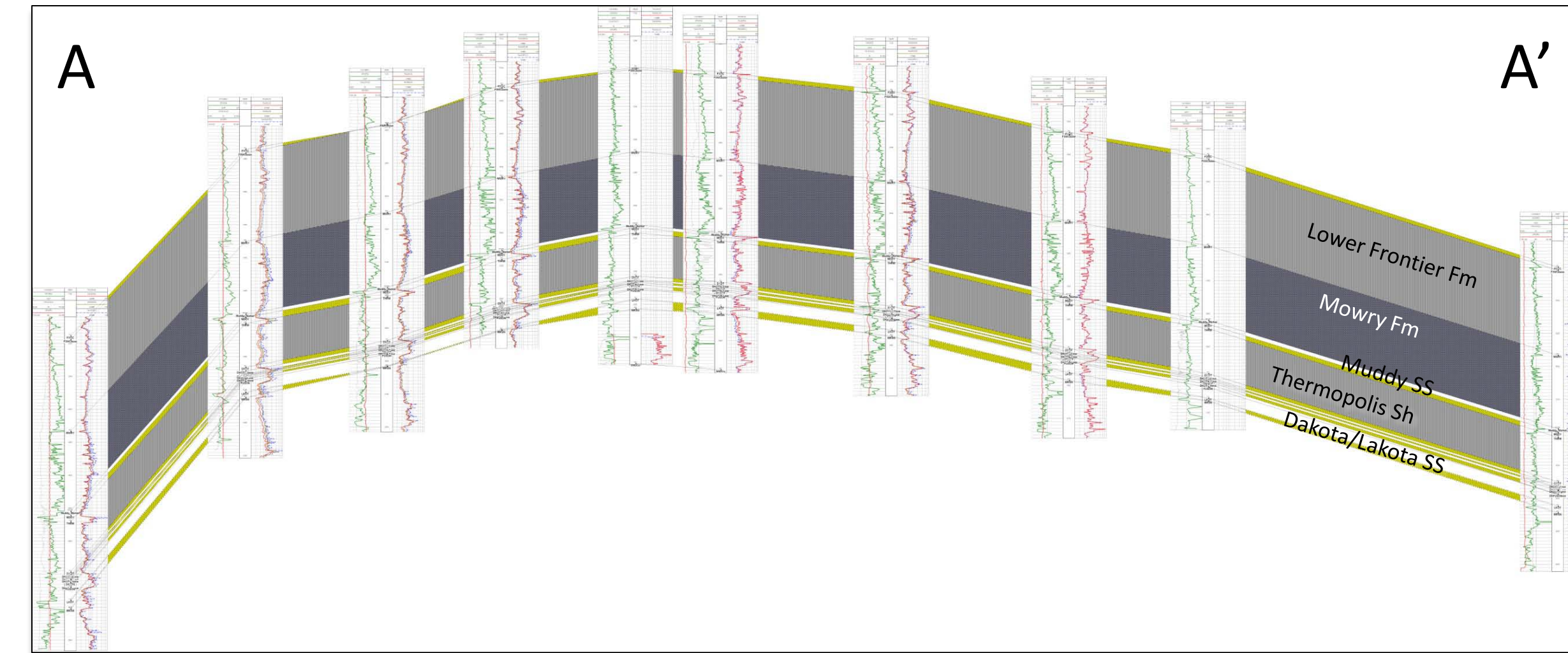
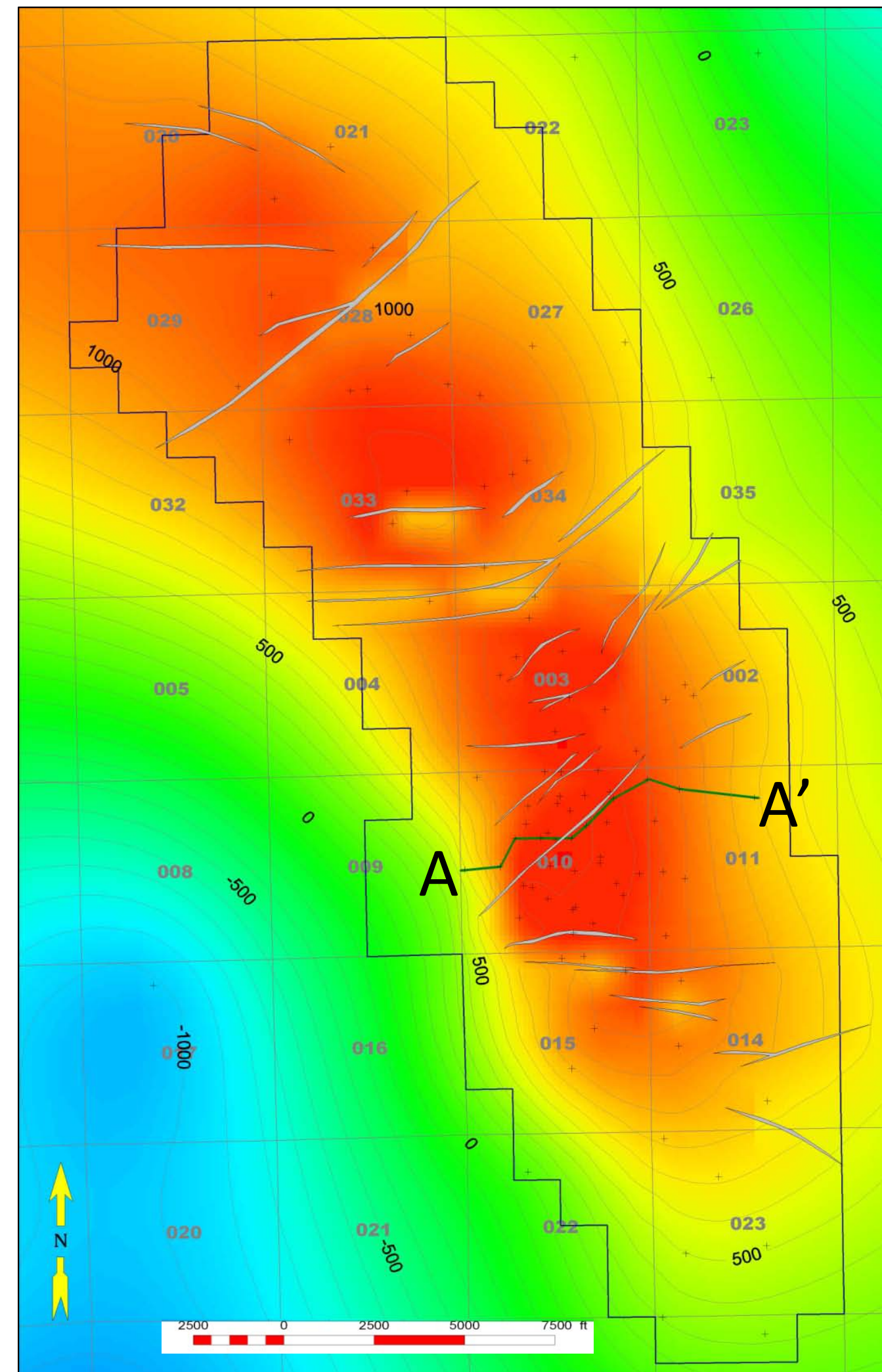
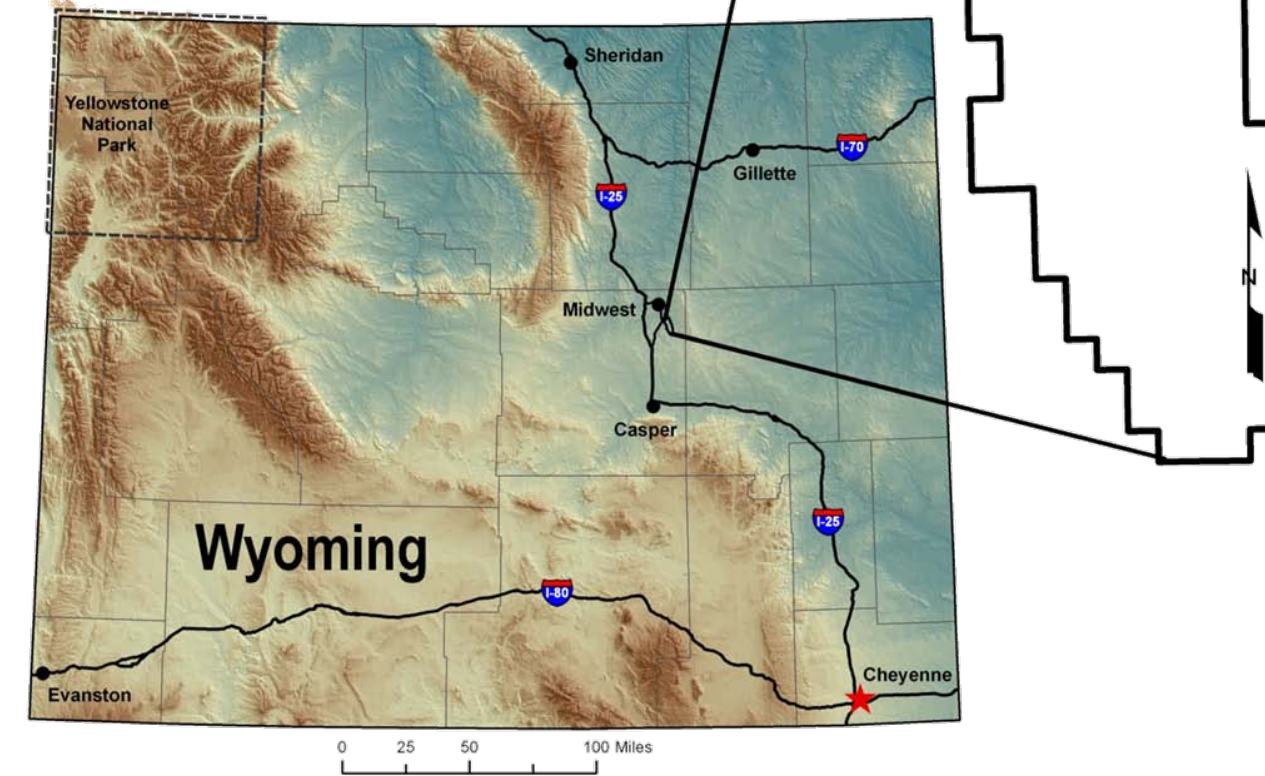


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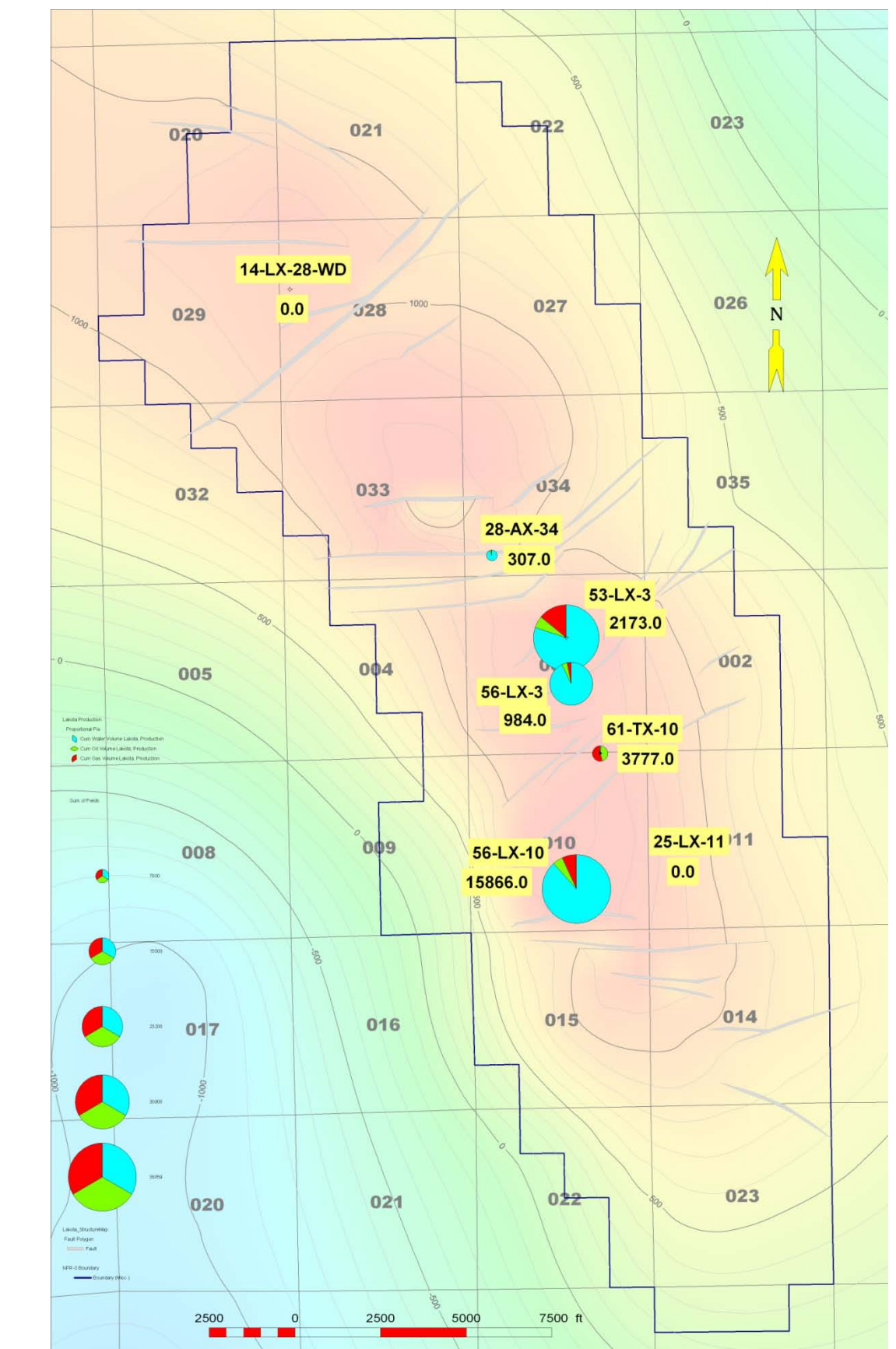
ABSTRACT

The Lower Cretaceous Lakota Sandstone is a conglomeratic sandstone that occurs on a regional scale throughout the Rocky Mountain province. The formation was deposited by fluvial systems transporting coarse-grained sediment east and north-east across broad alluvial plains. It has produced over 6,000,000 bbls of oil and 9.3 tcf of gas in the Powder River Basin in northeastern Wyoming. Since the opening of Naval Petroleum Reserve No. 3 to full production in the mid 1970's, over 194 MMCF of gas and 23,000 bbls of oil have been produced at Teapot Dome from the Lakota Sandstone. All of the production has come from the middle and southern half of the field. In 2001, 3D seismic data was acquired over Teapot Dome. This data shows an abrupt thickening of the Lakota Sandstone in the northern part of the field, which is confirmed with well data. In the southern two thirds of the field, the thickness of the Lakota Sandstone averages around 15 feet thick. The Lakota interval in northern third of the field averages around 45 feet in sand thickness and a few of the wells contain very thick deposits of over 70 feet of sand. Openhole log data show that these wells contain very good reservoir quality rock with average porosity around 16 percent. These thicker deposits however, are not laterally extensive and create distinct bull's-eyes on thickness maps. By co-rendering different seismic attributes together, and by creating stratal slices through the Lakota interval, some sinuous trends appear in the seismic data that otherwise are not apparent. Analyses of the seismic and well data show the sinuous trends coincide with the wells containing the anomalously thick Lakota sections. These features may represent meandering stream channels where the thickest sand deposits accumulated during deposition. Where penetrated, the thicker sandstones appear to be wet with minor oil and gas shows, but there may be further production possibilities higher on the Teapot Dome structure.

The Naval Petroleum Reserve No. 3 (NPR-3) is located in northeastern Natrona County, Wyoming within the Teapot Dome oilfield.



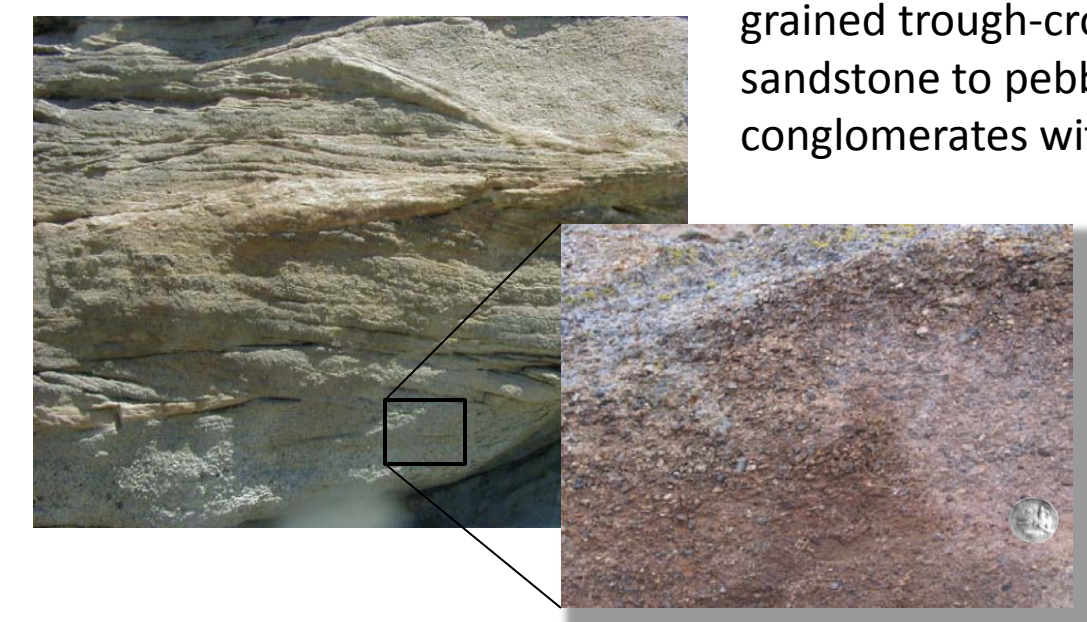
Structure map and cross section A-A' showing the asymmetric structure across the Lower Cretaceous strata. The map shows the structure across the top of the Lakota Sandstone including faults picked from 3D seismic data.



Map showing production pies and cumulative oil produced from the Lakota Sandstone at Teapot Dome. Note the high water cuts from all the wells. Cumulative production for the entire field is 23,107 bbls of oil (as of December 2005).

Period	Formation	Thickness (ft)	Depth (ft)	Production
Quaternary	Alluvium	0-50		
	Fox Hills Sandstone	100		
	Lower Shale	460		
	Mesaverde Group	340		
	Teapot St	325		
	Thompson	470		
	Bull's Head	480		
	Parkman St	480		
	Sutton St	36	195	
	Shannon St	120	515	435
Upper Cretaceous		1355		
	Nebraska Shale	450	1990	
	Carlisle Shale	240	2440	
	1st Wall Creek	160	2600	
	2nd Wall Creek	245	2840	
	3rd Wall Creek	65	3085	
		175	3150	
		5	3225	
		265	3330	
		230	3595	
Lower Cretaceous	Mowry Shale	15	3825	
	Muddy Sandstone	135	3940	
	Thermopolis Shale	85	3975	
	Dakota	18	4060	
	Morrison	270	4070	
Jurassic	Sandwich	95	4340	
	Upper Lower	150	4435	
	Lower	80	4585	
Triassic	Chugwater Group	28	4685	
	Red Peak	520	4885	
Permian	Goose Egg	320	5205	
	Teedley	320	5525	
	Armidon	160	5685	
Pennsylvanian	Madison	360	6045	
	Madison	4365		
Devonian through Cambrian	Un differentiated	780		
	Granitic	7885		

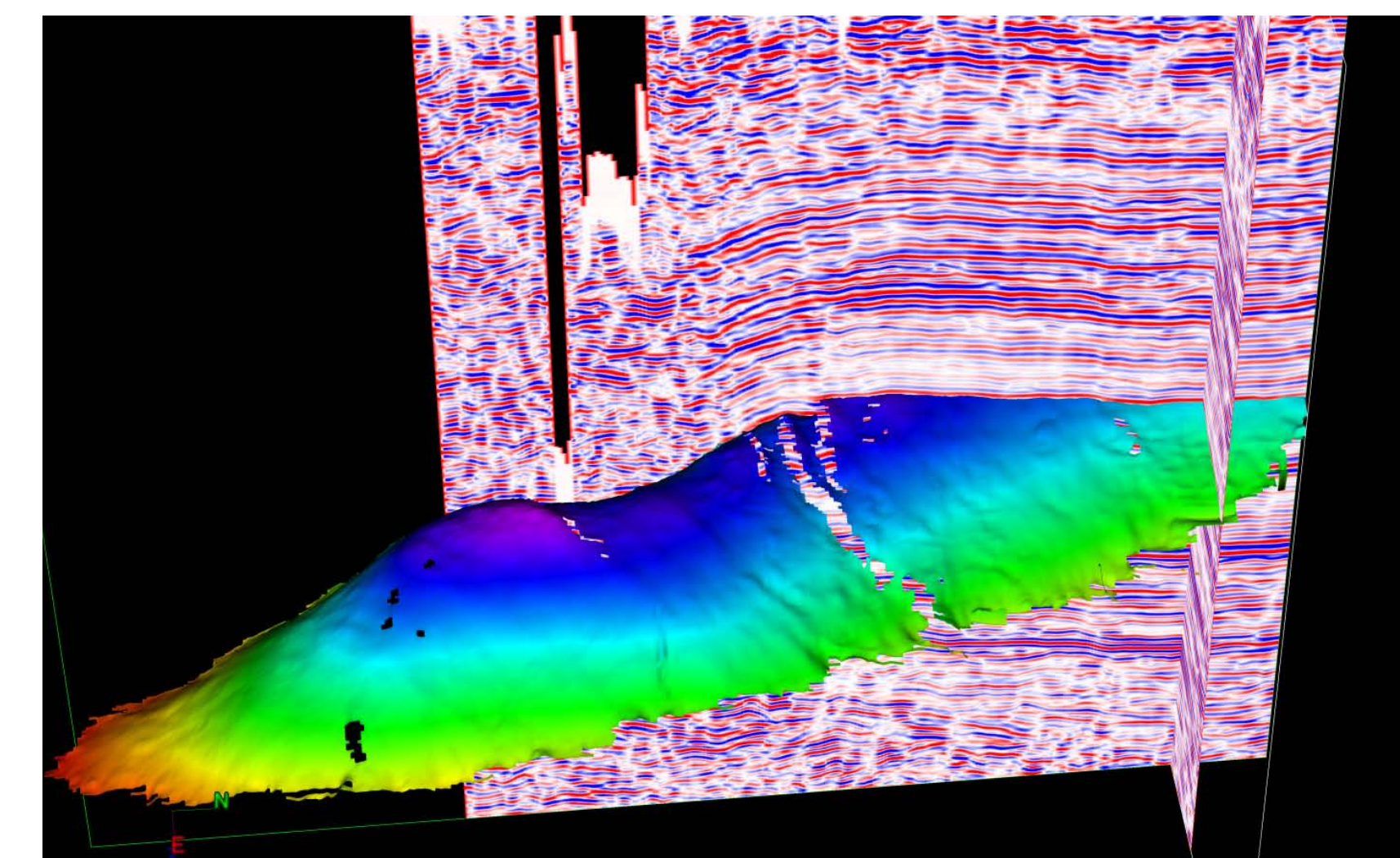
Stratigraphic Column showing geologic units at Teapot Dome. The Lakota Sandstone comprises the basal Cretaceous strata of the Powder River Basin in northeastern Wyoming and unconformably overlies the Jurassic Morrison formation. The Lakota sands were deposited by fluvial systems that transported sediments across a northward-sloping paleoslope (Gustason and Ryer, 1985; Muller and Dolson, 1988).



Outcrop photo showing a variability of grain size and bedding in the Lakota Sandstone ranging from medium grained trough-cross stratified sandstone to pebble-sized conglomerates with massive bedding.



Aerial view above NPR-3 looking to the south. The Upper Cretaceous Parkman Sandstone highlights the asymmetric doubly-plunging anticline that forms Teapot Dome. Teapot Dome is cored by a west-verging basement reverse fault (Photo courtesy of John Lorenz).



3D view showing time-structure of Lakota Sandstone interval with seismic panels in both the cross-line and in-line directions.

Total Petroleum Systems (TPS) and Assessment Units (AU)	Field Type	Total undiscovered resources											
		Oil (MMBbl)				Gas (BCF)				NGL (MMBNGl)			
		F95	F50	F5	Mean	F95	F50	F5	Mean	F95	F50	F5	Mean
Basin-Margin Substrata Play (1996)	Oil	0.00	0.00	113.00	20.10	0.00	0.00	113.00	20.10	0.00	0.00	3.39	0.60
Basin-Margin Anticline Play (1996)	Oil	1.30	5.50	16.50	6.80	0.78	3.30	9.90	4.06	0.02	0.10	0.30	0.12
Leo Sandstone Play (1996)	Oil	0.00	50.90	261.40	81.40	0.00	3.65	15.68	4.88	0.00	0.00	0.00	0.00
Upper Minisolas	Oil	98.20	247.20	1,065.20	422.20	7.20	34.86	62.31	21.24	0.00	0.00	0.00	0.00
Lakota Sandstone Play (1996)	Oil	2.80	23.30	126.40	53.80	1.12	9.32	50.56	21.52	0.00	0.00	3.54	1.51
Muddy Sandstone Play (1996)	Oil	16.20	127.20	608.10	247.20	76.20	244.90	119.50	83.20	0.00	0.00	17.14	4.06
Muddy Sandstone Play (1996)	Gas	3.50	28.40	118.40	58.10	10.50	85.20	355.20	177.30	0.74	5.96	24.86	12.41
Deep Frontier Sandstone Play (1996)	Oil					22.40	155.50	574.20	271.80	1.24	9.23	34.46	15.31
Turner Sandstone Play (1996)	Oil	4.80	38.50	105.00	48.20	19.20	146.00	420.00	192.20	0.96	7.30	21.00	9.86
Turner Sandstone Play (1996)	Oil	2.80	16.20	37.50	21.10	4.20	24.30	56.25	31.65	0.53	3.04	7.03	3.96
Eastern Basin Margin Upper Ft. Union Sandstone AU	Gas	5.90	50.60	148.10	67.80	4.72	40.48	118.48	54.24	0.26	3.24	8.48	4.34
Mesaverde-Lewis Play (1996)	Oil	5.20	43.20	124.20	58.10	5.20	43.20	124.20	58.10	0.26	3.03	8.69	4.07
Eastern Basin Margin Upper Ft. Union Sandstone AU	Gas					0.01	0.01	107.43	27.37	0.01	0.01	0.01	0.01
Total Conventional Resources		80.70	629.70	2,613.80	1,131.20	80.13	602.81	2,253.25	1,011.82	5.89	38.80	129.89	61.86

Table showing USGS assessment of undiscovered reserves for the Powder River Basin. This assessment shows a 50 percent probability of 23.3 million barrels of oil and 9.32 billion cubic feet of gas reserves yet to be discovered in Powder River Basin (http://pubs.usgs.gov/fs/2006/3135/pdf/FS06-3135_508.pdf).